Once the turfgrasses have been established, a maintenance program has been implemented, and buildings, roads and parking lots are completed, the golf course will be opened for play. If the design and construction of the course was done properly, the job of the superintendent will be made easier and the operations more efficient.

At this point, a whole new set of issues must be dealt with successfully – course operations combining playability, profitability, and environmental protection.

A complete management plan and pollution prevention plan should be developed before course operations begin. This plan is developed under the concept of *Integrated Course Management* or ICM. The plan will include best management practices (BMP's) to ensure that any adverse impacts to the environment are minimized. The procedure to develop the ICM Plan is as follows:

1. Identify the people and agencies identified by the plan and identify responsibilities. This list would include owner, superintendent, employees, local officials, and all associated government agencies.

2. Develop a communications plan to ensure good relations with all individuals or groups that should be apprised of course operations, especially neighbors.
3. Define the distinct golf course management areas. Management areas include greens, fairways, rough areas, bunkers, water features, natural areas, and maintenance areas.

4. Schedule to periodically perform an 'Environmental Audit' of operations that will include:
- Stormwater management
- Irrigation management
- Integrated pest management
- Soil fertility management
- Maintenance area management

5. Develop a contingency plan for emergencies such as fertilizer or pesticide spills.

6. Prepare record keeping forms and procedures.

Irrigation Management

One of the greatest environmental concerns facing golf courses is their use of water for turfgrass irrigation.
Careful water use is not only environmentally and fiscally sound, but also is essential to promote healthy turfgrass that is better able to tolerate environmental stress and resist insect pests, weeds, and disease. Healthy turfgrass subsequently requires less water, fertilizer, and pesticides. More efficient water use reduces the amount of water removed from streams, resulting in less disturbance to aquatic systems. Less water taken from wells reduces impacts on the ground water levels and wells in that locality.

A water conservation scheme depends on several factors: soils, terrain, course layout, grass selection and acreage, irrigation system design and control, and whether or not treated sewage sludge effluent is available. Operational considerations affecting irrigation water management will include irrigation quantity and frequency, fertilization program, pest management, and mowing. Most new golf courses are designed with water conservation in mind.

Reducing Irrigation Needs:

1. Layout

Golf course layout has a large impact on water use. Most courses are between 150 – 200 acres in size. Of

this, about 80 acres will be irrigated. Narrowing fairways and incorporating warm season native vegetation such as switchgrass, bluestem, and indiangrass in roughs can lower this amount. Prioritize areas for irrigation:

1. Greens and collars
2. Tees
3. Greens approaches
4. Fairway landing zones
5. Other fairway areas
6. Shorter rough areas

This priority system is similar to the golf of earlier days, where fairways, greens, and tees represented the only high maintenance areas of the course, and the majority of acreage was in a more natural state. This concept saves water and has little or no effect on the playability of the course.

2. Turfgrass Selection

Significant water savings are possible with the appropriate selection of locally adapted turfgrasses for greens, fairways, and planted rough. Grass species cultivars can differ significantly in water uptake rate.

A general summary of the water use and drought tolerance ratings for various typical golf course grasses is presented in Table 1, below.

Of course, water use is only one factor in turfgrass choice. The best approach is to identify species and cultivars that perform best under the intended use in terms of pest resistance and vigor. Then compare desired species within water use data to make the final selection. This combined approach will result in grasses that require less fertilizer, pesticide, and water.

Table 1: Water Use Characteristics of Some Common Golf Course Turfgrasses

Fine leaf fescues:

- Use the least water and suffer the least permanent drought damage
- Low wear tolerance
- Good for some rough and other low wear areas

Perennial ryegrasses:

- Medium – high water requirements
- Moderate drought sensitivity. Can be improved with optimum fertility conditions.
- Low cold tolerance
- Widely used on fairways, tees, and roughs
- High disease susceptibility
- Good wear tolerance

Creeping bentgrass:

- High water use
- Used primarily on greens and fairways
- Variable disease tolerance
- Moderate drought tolerance

Colonial bentgrass:

- Lower water requirements and higher drought injury recovery than perennial ryegrass
- Appropriate for fairways
- Lower cold tolerance

Kentucky bluegrass:

- High water requirements
- High summer dormancy mechanism

Tall fescue:

- Extremely drought tolerant
- Very high water use rate
- New dwarf varieties maintain acceptable quality with less fertilizer and pesticide
- More saturation tolerant than fine fescues
- Less desirable playing surface

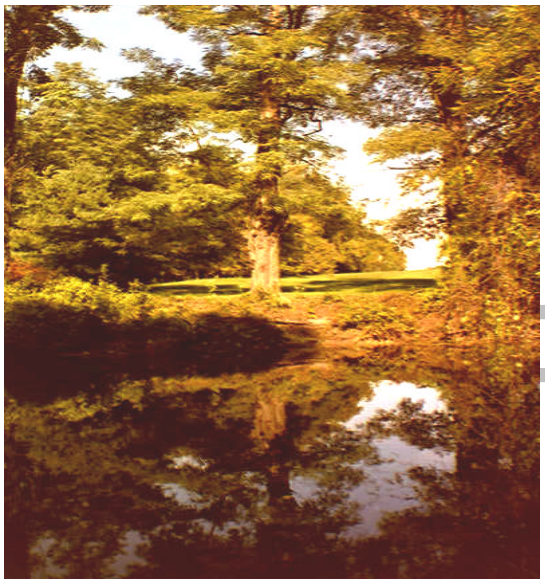
3. Fertility and Water Use

Nitrogen and potassium can be applied at rates that provide adequate nutrition while minimizing water use. In general, lower nitrogen application rates reduce water use. Heavily fertilized plants have greater growth rates, have wider leaves, are often denser, and often have shallower root systems. These factors lead to greater water demand. Potassium can improve turfgrass resistance to drought injury, and effect on water use is insignificant. Higher potassium rates may be advisable if 'deficit irrigation' (irrigating at *less* than the minimum rate) is practiced.

4. Infiltration Issues

Low infiltration rates reduce irrigation efficiency and increase runoff of water and potential pollutants. Turfgrass cultivation and aeration promote higher infiltration rates and a deep, vigorous root zone, which uses soil moisture more effectively.

Traditional hollow-tine core cultivation of greens and tees should occur twice a year to control compaction and reduce thatch. Water injection, solid tine cultivation and spiking are other methods which can be used throughout the summer to maintain good infiltration rates on greens and tees.



Irrigation Supply

If irrigation water is to be taken from natural surface waters, a surface or ground water withdrawal permit will be required from the NJDEP. Water sources for irrigation supply should be evaluated and prioritized in order to reduce impacts on natural water sources.

A prudent priority of sources might be:
1. Stored stormwater in ponds or detention basins onsite
2. Treated sewage effluent
3. Public or municipal water supplies
4. Existing natural surface waters
5. Private wells

This prioritization results in best use of available low-impact water sources.

Irrigation BMP's

Fine tune irrigation practices and maintain peak irrigation system efficiency. Careful use of the irrigation system will result in a better quality turf. Avoid over irrigation in the spring. A continually saturated condition in the springtime root zone prevents the development of a deep, fibrous root system, which means trouble for summer survival. Critical irrigation best management practices include:

- Use a soil probe before irrigating to determine existing soil conditions
- Apply irrigation water as uniformly as possible (variability of soils and turf types will require customized application in some instances)
- Apply water only as fast as the soil can accept it. To avoid puddling and runoff, use short duration cycles
- Irrigate when there is little wind and avoid mid-day irrigation during peak evaporation periods
- Utilize drip irrigation for tree and shrub areas and reduce or eliminate irrigation for the driving range

A well designed, properly installed, maintained and managed *automatic* irrigation system usually provides the best means of conserving water. Water savings of 40% to 75% have been documented on golf courses that have converted from manual to automatic.
Regardless of system type, it should be operating at peak efficiency.
Principles for efficient operation are:

- Repair all leaks
- Check nozzle size as it relates to available pressure and resulting coverage
- Check for nozzle wear and replace as needed
- Use half-circle sprinklers where applicable
- Check pump performance and other pumphouse systems
- Test sprinkler application rate and evenness often

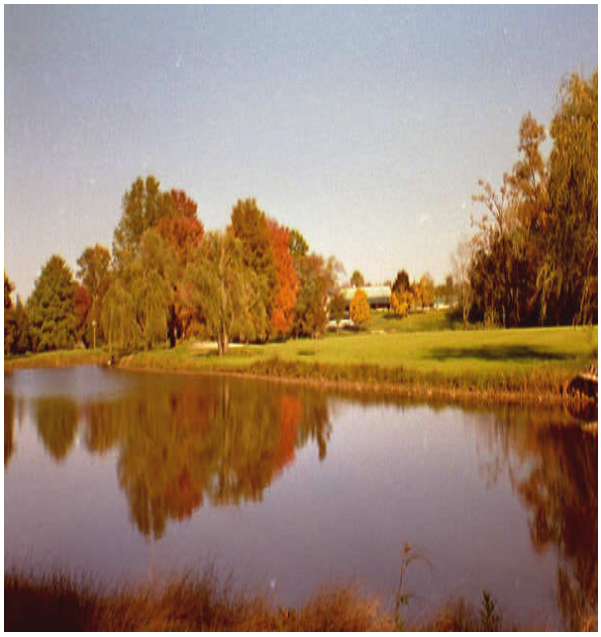
(Preceding from: Audubon International, A Guide to Environmental Stewardship on the Golf Course, Selkirk, NY 1996)

Cultural Turf Management

Healthy turf is the goal of cultural management practices. Turf that is healthy and vigorous is better able to propagate and resist weeds, insects, and disease. A good cultural management program recognizes that cultivar selection, soil improvement, mowing, irrigation, and fertilization are all interdependent and synergistically produce a result. This section describes general management techniques to prevent or mitigate diseases, weeds, insects, animals, and aquatic pests.

Cultivar Selection

- Select turfgrass cultivars adapted to the local climate and growing conditions. Poorly adapted species have higher maintenance requirements, are more stress prone and may require more fertilizer and pesticides. Information on cultivars may be obtained from Rutgers Cooperative Extension, trade journals, and seed companies.
- Conserve native grass species and establish diverse grass communities whenever practical. Native or diverse grass communities are generally more resistant to pest outbreaks. However, these types are less adapted to high traffic, so they should be used in rough and out of play areas.



Soil Improvement

- Prevent soil compaction (page 9)

- Conduct soil testing early in the construction process. Early evaluation allows time to review results and plan amendment strategies. Also, soil acidity and phosphorous adjustments are more effective if lime or phosphate can be worked into the root zone. Sample soil often (every other year) once turfgrass is established.
- In areas of low organic matter, incorporate compost or composted sewage sludge meeting NJDEP requirements as 'exceptional quality' biosolids. (NJDEP Permits required.) Organic soil amendments can improve the soil water holding capacity, reduce runoff, promote the soil microbiological ecosystem, and reduce water quality risks of pesticide application.

- In areas of compacted soil, use core cultivation or similar soil aerators. Opening the compacted surface improves infiltration, reduces runoff, improves fertilizer uptake and enhances root zone development.

Mowing

- Raise fairway mowing height and reduce mowing frequency. Slightly higher turf improves infiltration, decreases runoff, improves soil moisture retention, encourages deeper root systems, reduces mowing frequency, and discourages weeds. Ideally, no more than one-third of the grass blade is removed at one mowing.

- Ensure blades are sharp. Mowing with dull or pitted blades tears and sheds the grass leaves. This can slow growth, encourage disease and make for a ragged appearance. Additionally, mowing with sharp blades increases the decomposition rate of the grass clippings.

- 'Cut it and leave it' on fairways. Grass clippings that remain on the surface provide a natural source of organic matter and nutrients. However, clippings should be removed during disease outbreaks to contain the disease. If grass clippings must be removed, they should be spread lightly in the rough or other unmanaged areas away from surface waters, outside of buffer zones.

- Improve drainage in poorly drained areas. This will reduce risk of winter root injury and disease.

Fertility Management

Fertilizers are necessary to maintain healthy turfgrass that is under heavy use. The primary necessary turfgrass fertilizer nutrients are nitrogen (N), phosphorous (P), and potassium (K). Excessive applications of N and P can encourage weed growth, turf disease, and cause pollution of both ground and surface waters.

Surface runoff from established, healthy turf does not usually carry harmful amounts of N and P. The potential for nutrient polluted runoff increases in newly seeded areas, on steep slopes, when application is done at improper times, and during rehabilitation of depleted or damaged turfgrass.

The proper objective of a fertilizer management program is to supply plant nutrients at the proper time and in the proper amount to supply sufficient food for the turf with no excess.

- Develop and document fertilizer programs for each area of the golf course. Nutrient needs vary by cultivar, soil conditions, and use pressure. A fertilizer plan should address the different needs of

each area of the course. Application frequency, timing, formulation, and amount should be documented each time.

- Manage fertilizer applications according to weather and soil conditions. Never exceed Rutgers Cooperative Extension fertility recommendations.

- Avoid fertilizer applications during dry soil conditions just prior to significant rainfall events. Do not apply high N fertilizers on wet turf. Always avoid heavy applications of soluble nitrogen fertilizers. Instead, use light foliar feedings of soluble N concentrations.

- On coastal plain or similar coarse textured soils, use lower amounts applied more frequently in order to meet the turf nutrient requirements.

- Perform light feedings during the late fall near the turf dormancy date. This will reduce the need for early spring fertilization and eliminate the wintertime turf thinning common in the Northeast. Slow release temperature sensitive nitrogen fertilizers should be used for applications done late in the season. These fertilizers remain insoluble in cold temperatures, which reduces leaching to ground water. Slow release fertilizers should supply 50% of the nitrogen requirements.

- Maintain a fertilizer free transition zone around all surface waters, including stormwater detention facilities. Transition zone grasses that receive no fertilizer act as buffers or filter strips. This zone should be considered the upper area of the riparian buffer.

- Be moderate with fertilizer on newly seeded areas. Grasses lacking a fully developed root system are unable to assimilate high levels of nutrients. Use several light applications in the critical establishment phase.

Periodically conduct a soil-sampling program for each area of the course. The soil test program should include phosphorous, potassium, organic matter, micronutrients, and pH.
On intensively managed areas such as greens and tees, plant tissue analysis will be of more value.

Integrated Pest Management

Integrated pest management (IPM) ranks right with irrigation and fertility management in environmental priority.

The overall goal of golf course IPM is to promote healthy turfgrass that can withstand higher levels of pest pressure without significant damage. IPM prevents economically significant weed, insect, and disease levels through cost effective means and with the least possible hazard to humans, wildlife, non-target organisms and water resources. IPM can be challenging because the very nature of desirable golf course conditions (low cutting heights and heavy traffic during the hottest time of the year) create significant turf stresses.

The place to start formulating an IPM plan is to understand turfgrass growth, pest biology, and the factors that encourage pest infestation. The next issue to ascertain is the definition of treatment thresholds for determining when corrective action should be taken and the development of a pest scouting strategy and monitoring program to determine the effectiveness of control methods. Pest management methods and their success will vary by geographic region and even among differing areas within the same golf course.

Appropriate pest control methods can be both cultural and non-cultural in nature. Cultural management offers pest-specific methods for blocking or reducing the extent of a pest problem. Non cultural management employs biological controls or pesticides to control pests posing an economic threat to turfgrass resources.

Problem Identification:
Pest Biology

Pests, in the IPM context, include those weeds, insects, diseases, and animals that reduce golf course quality. The correct selection and effective implementation of IPM techniques relies upon a thorough knowledge of pest biology, including pest identification, life cycle, and conditions favoring population growth.

A successful IPM program relies on effective scouting and diagnosis. Scouting is the process of identifying pest types, populations, and field locations. Scouted populations are compared to known population levels which can then be compared with established threshold levels to determine appropriate treatment measures. Walking the course often is a critical facet of the scouting process.

- Base the scouting program on the common pests known locally to affect the turf, trees, and surface waters. Don't go 'looking for zebras in a field of horses.'

- Perform regular, systematic inspections to identify pest problems. Standardized methods for survey patterns, sample numbers and sizes, and turf type descriptions will permit effective comparisons of recorded information. Initial scouting should entail a detailed hole-by-hole survey, with any problems noted on a map. In case of disease outbreaks, weather conditions should also be recorded.

- Base scouting frequency on pest occurrence. Scouting frequency depends on the type and extent of the pest problem. Regular scouting may be done weekly, but daily checks may be required during outbreaks or periods that favor pest establishment. Pay particular attention to areas that historically experienced pest outbreaks.

- Accurately identify pests. Damage caused by different pests is often similar in appearance. If in doubt, submit samples of the pest, turf, or soil to a specialist for analysis. Further assistance may be available from Rutgers Cooperative Extension.
- Properly diagnose the stage and severity of the pest problem. Treatment decisions rely on accurate diagnoses. Once damage has occurred, it is often appropriate to facilitate turfgrass recovery and prevent recurrence of a particular pest rather than target the pest itself.

- Monitor pest problems to determine effectiveness of treatment regime. Use a standard, replicable method to evaluate IPM management decisions and treatments.

- Keep accurate and complete records. Record scouting observations, weather conditions, management decisions, control methods and strategy effectiveness.

IPM Treatment Thresholds

IPM Treatment thresholds take into account population, damage, and economic thresholds. It may not be economical to treat a pest problem where the damage is minimal and the problem is not expected to intensify to the point of causing economic impacts.

Input and agreement is essential between course owners and operators for successful implementation of treatment thresholds. When determining treatment thresholds, course managers must define:

- population thresholds for each potential pest
- damage thresholds for each area of the golf course, especially greens, tees, fairways, and rough. This is especially important to establish because there are some portions of the course (greens) where practically NO pest damage is acceptable, while others (rough, some fairway) where a moderate level is tolerated.
- unit costs of standard cultural and non cultural control methods.

Disease Control

Biological or parasitic turfgrass diseases are a result of bacteria, viruses, fungi, and nematodes. Diseases may be caused by environmental conditions such as excessive moisture, optimum temperatures, or damage from foot and vehicular traffic. Cultural controls should be the first and primary defense against turfgrass disease.

The following cultural practices are intended to reduce the threat posed by a range of fungal diseases.

- Implement an area-specific scouting program.
- Use improved, disease resistant turfgrass varieties.
- Manage soil fertility, weed control, and soil moisture level to maintain a vigorous turf stand and increase disease resistance.
- Avoid early evening irrigation, which extends leaf surface wetness. Early morning irrigation removes dew, helping turfgrass to dry faster and reducing the potential for disease outbreaks.
- Facilitate proper turf surface aeration. Turf aeration practices include spiking and coring. Aeration increases oxygen in the root zone, lowering moisture and reducing the conditions favorable for some diseases.

- Improve sunlight penetration and air movement across turf surfaces, especially tees and greens.

Weed Control

Weed control is based on recognizing the biological and morphological differences between weeds and turfgrass and focusing control measures at the more susceptible phase of the weed life cycle. Here are some cultural weed control practices:

- Always use the highest quality seed stock available.
- Prevent the spread of weeds by equipment.
- Schedule control operations before weeds begin to produce seed. Such control measures vary with the type of weed. For example, timely mowing of certain weeds will help prevent seed production and can starve plant roots. This is ineffective for low growing, prostrate weeds that flower below the cutting height.

- Hand pull isolated small weed outbreaks, such as dandelions on green collars.

Insect Control

Insect pests can occasionally pose a significant risk to turfgrasses in New Jersey. Insecticides should be used as little as possible, since they pose a greater risk to fish and wildlife than most herbicides and fungicides. There are a number of cultural insect management practices that can reduce the need for insecticides:

- Select native or insect resistant trees, shrubs, and ornamentals.
- Avoid the use of insecticides on non-turf areas. Use instead non chemical alternatives such as insecticidal soaps. *Bacillus thuringiensis*, which is a bacterium that infects the larvae of some moth species; and diatomaceous earth are good alternatives. There are many others.
- Avoid insecticide based mosquito control. Maintain a level of flow in water bodies whenever possible to reduce mosquito habitat. Create optimum conditions for mosquito predators such as bluebird houses and bat houses.

Non-Cultural Pest Management

Non cultural methods for pest control include biological controls and pesticides. These types of measures should be considered when cultural techniques fail to keep pest populations below threshold levels.

Biological Controls

Pests can thrive in single species grass communities. Biological controls involve the introduction of control organisms or introduction and encouragement of natural enemies. Control organisms include pathogens (disease causing viruses, fungi, bacteria, nematodes and protozoa), predatory or parasitic insects, bats and birds. While biological controls show promise, their application is relatively new and should be carefully considered. Pest control results can be variable, and many biological agents are expensive. An

important point to remember with respect to biological control practices is to maintain diverse populations by preserving endemic vegetation and wetlands within and adjacent to the golf course.

Pesticides on the Golf Course

Following are some basic pesticide management concepts:

Pesticides will usually reduce pest damage to turfgrasses but can also have serious environmental effects. To protect water resources, careful consideration must be given to pesticide selection and application. Integrated pest management programs should always incorporate the following principles:

- Minimize chemical use through cultural control measures, if possible.
- Select the least toxic, least persistent, least mobile and most pest specific NJ registered pesticide.
- Apply the pesticide at the pest's most vulnerable life cycle stage.
- Apply the pesticide at the minimum required rates to the minimum area necessary.
- Use the pesticide in strict accordance with the product label directions and guidelines.
- Avoid continually using pesticides of the same chemistry or active ingredient mode of action to avoid buildup of pest resistance.
- Be aware of the 36-48 hour weather forecast.
- Adopt a notification program for neighbors when pesticides are to be applied near course boundaries.

Pesticide Selection

There will always be more than one type of pesticide that is effective and registered for a specific use. Pesticide selection must consider environmental factors, as well as the pesticide toxicity, persistence, tendency to accumulate in living tissues, solubility, and soil adsorptive characteristics. These factors all play an important role in the movement of pesticide surface runoff and leaching to ground water.

Environmental criteria for profiling and selecting pesticides are listed below.

- Profile the important physical environmental factors affecting chemical mobility for each area of the golf course. Several factors are: soil organic matter, clay content, texture, permeability, subsoil texture, and drainage, affect pesticide movement and should be factored in chemical management

plans. For example, the higher the percentage of organic matter and clay content in the soil, greater is the soil ability to adsorb chemicals and decrease leaching. In contrast, sites featuring coarse textured soils offer high permeability, which makes it easier for mobile chemicals to leach down to the water table. Golf courses built over karst, fluvial or alluvial sandy-gravelly complexes also run higher risk of leaching and runoff.

- Avoid pesticides which are very toxic to birds, fish, and wildlife.

- Eliminate pesticides which are persistent and can bioaccumulate. Such substances, which may include pesticides and pesticide metabolites, pose the greatest environmental risk. Pesticides with a soil persistence of greater than 21 days, a soil adsorption (Koc) value of less than 300 and a solubility of greater than 30 mg/l should be used with extreme caution. These general guidelines are especially important in areas with coarse textured soils, soils with low organic matter, and steep slopes near surface waters.

- Avoid applying wettable powders in potential runoff areas. Wettable powders exhibit relatively high runoff rates, characteristically (5% of amount). Better alternatives are water-soluble powders or emulsifiable concentrates.

- Avoid applying pesticides in late fall and winter in flood prone or ponded areas. Some waterfowl species, both resident and migratory, are attracted to flooded fields. They can be poisoned through ingestion of persistent pesticides, particularly granular formulations.

Pesticide Application

It is the applicator's responsibility to take
appropriate precautions to protect non-target organisms from exposure. All pesticide applicators and supervisors must be trained and licensed through the Pesticide Applicator Licensing Program of New Jersey, a joint venture of Rutgers Cooperative Extension and NJDEP.

- Read product labels carefully and completely. Apply chemicals only according to the manufacturer's recommended usage and only for registered uses. Pay particularly close attention to the delivery rate and spray volume per unit area.

- Properly calibrate all pesticide sprayers prior to use. Accurate calibration will assure better pesticide application and reduce the risk of chemical drift, runoff, and turf stress caused by misapplication.

- Minimize drift. There are a number of techniques that can be employed:
  1. Closely monitor weather conditions and forecasts to comply with application guidelines. Avoid application when wind speeds exceed 5 miles per hour or when winds are blowing toward adjacent non target sensitive areas. Avoid conditions of temperature inversions – they can lead to vapor cloud formation.
  2. Use low pressures and large droplet nozzles if practical. Large droplet nozzles *can* adversely affect weed control.
  3. Consider use of drift inhibitor or retardant additives.
  4. Mix a spray pattern indicator with pesticide when spraying near a pesticide free buffer area.
  5. Use wind skirts, guards, and shrouds on all sprayers.

- Do not fill pesticide sprayers near water courses and drains.
- Do not leave sprayers unattended while filling.
- Maintain nozzles, hoses, tanks, pumps and all other application-related equipment.

Pesticide-Free Buffer Zones

Use of pesticide free zones reduces the chance of pesticide drift, runoff or leaching into sensitive areas. Surface waters to be protected by pesticide free zones include all water courses (including stormwater ditches), ponds, lakes, and wetlands.
Maintain a minimum 35 foot pesticide free zone adjacent to watercourses or water bodies. No pesticide or application equipment may enter the zone. Set a buffer along the pesticide free zone. Generally, a 15 foot buffer zone should be added to the width of the pesticide free zone. In the buffer, pesticide application equipment may travel, but pesticide application should be avoided.

Other Pest Considerations

Animal Control

Certain wildlife can pose problems to golf courses and golfers. Only non chemical control measures should be considered, since poisons for terrestrial wildlife are highly toxic and can affect non target life.
Consult with NJDEP Div. Of Fish and Game for specific recommendations.

Canada geese can become a problem
on golf courses, polluting ponds and destroying plants on shorelines. There are some methods of control that have been successful in some areas: 'scare' techniques such as dogs, flagging, and decoys; swans; egg addling: and most importantly, *habitat modification*. This entails keeping as much vegetation on the shoreline and a 25 foot wide buffer area at a length above the goose's head height. A mix of trees, shrubs, and stiff-stemmed grasses can be used.

Use traps to manage pest gophers, muskrats, and beavers if sufficient damage to the golf course warrants action. Move trapped animals to non developed areas, or work with NJ Division of Fish, Game, and Wildlife to relocate off the property.
Use tree guards to prevent girdling by rabbits, mice, and squirrels.

Aquatic Pest Control

Golf course developments use ponds as part of landscape design, stormwater management, and for irrigation water. Excessive growth of algae and weeds can reduce dissolved oxygen levels, produce noxious smells and discolor the water as the vegetation decays. Some simple practices can be used to reduce this hazard:

- Aerate ponds. Fountains or compressors with underwater bubbling lines will maintain dissolved oxygen to levels that sustain fish and macroinvertebrates. Algae will also be reduced. Small ponds may use a solar-powered low h.p. unit.

- Use mechanical methods for removing vegetation and decayed debris.

- Use non-toxic water shading dyes to impede sunlight penetration, which will reduce weed growth.

- Utilize aquatic bio controls with caution. Introducing grass carp for weed control, or snails, weevils, or midges can have implications for non target organisms. Consult with NJDEP for guidance and required permits. Biological control specialists should be consulted for any implementation of these type measures.

Wildlife Habitat Considerations

Roughs and non-play areas of the golf course can be managed to provide habitat for a diversity of wildlife species. The location, size, and layout of your course property and the variety of existing habitats will have an effect on what can be done. In most cases, however, several concepts can consistently be followed:

Wildlife Cover Enhancement Projects:

- Leave woodland understory whenever possible
- Leave large dead trees standing for dens if not a safety hazard
- Use trimmings or downed limbs to create brush piles for small mammals
- Mount and monitor nest boxes for local valued species such as wood duck, eastern bluebird, etc.
- Protect or enhance habitats for threatened and endangered species
- Designate ‘no-mow’ areas
- Connect detached habitats with woody wildlife corridors

Wildlife Food Enhancement Projects:

- Choose food sources for hummingbirds, butterflies, or songbirds in landscaped and garden areas
- Emphasize native food plants in landscaping
- Mount and maintain songbird feeders

Water Enhancement:

- Buffer shorelines around ponds with native aquatic plants
- Mount an osprey nesting structure

- Enhance diversity of wetland areas
- Curtail any streambank erosion problems with soil bioengineering practices such as brush mattressing, live fascines, wattling, and others
- Consult USDA-Natural Resources Conservation Service for sources of materials and specifications

Audubon Initiative

Conservation organizations such as Audubon International are beginning to participate actively with the golf industry. One of the most successful examples has been the Audubon Cooperative Sanctuary Program for Golf Courses established by Audubon International and the United States Golf Association. More and more courses are being designed and managed with the guidelines established by the sanctuary program. The program was initiated to enhance wildlife habitats on existing and future golf courses and to improve public recognition of golf courses as important open spaces. (Love, 1992)

(Much of preceding adapted from: Audubon International, A Guide to Environmental Stewardship on the Golf Course, 1996 Selkirk, NY)

Maintenance Facility
Best Management Practices

The maintenance area is the primary storage and work area at the golf course. It is an area also used for mixing chemicals, servicing equipment, and storing waste. The management goal in this area is the prevention of substance release outside of the maintenance area.

Extensive guidelines exist for storing, handling and mixing of pesticides, fertilizers, fuel and other maintenance materials. This section highlights general management practices, but golf course managers must adhere to local and federal (FIFRA) requirements.

Always ensure that no possibility exists for pesticides, washwater, fuel, oil, or other maintenance products for runoff to water bodies or well heads.

Pesticide and Fertilizer Storage

Maintain a well designed pesticide storage area that includes the following features:
1. Distinct and separate lockable facilities for storage
2. Fire resistant construction materials
3. Spill containment measures: a sealed concrete floor with curb or sealed wall with sump spill recovery area and available clean up and absorption materials
4. No floor drain, unless it goes to the sump recovery
5. Insulation from extreme temperatures
6. Storage shelving attached to the walls, with liquids stored below dry materials.
7. Good lighting and ventilation
8. Telephone
9. A wash station including shower and eyewash
10. Warning signs

Designate a covered area solely for the purpose of pesticide mixing. This area will be adjacent to the storage building. It will have a concrete, sloping curbed floor with sump recovery, no floor drain, and a wash station.

Keep accurate records of all pesticides bought, amounts used, and amounts remaining. Update after every application.

Avoid stockpiling excessive amounts of pesticides. Only buy pesticides for one season's use at maximum. Better is one *month's* use. Dispose of empty containers according to NJDEP regulations.

Properly dispose of rinse water produced from rinsing containers or application equipment:

- Drain container and equipment rinse water into spray tanks and apply to the treatment area. When treating an area of the course, leave a small area untreated for the purpose of rinse water application.

Maintenance Equipment and Fuel Issues

Use a covered equipment maintenance area that incorporates the following features:
1. It is located away from surface waters and drainage courses
2. Protected from outside runoff
3. Has a concrete floor with raised curb and no floor drains, unless they run to a spill recovery sump
4. Spill containment and absorptive materials close at hand
5. Drip pans

The fuelling area should also be located way from surface waters, and be adjacent to the equipment area; it should be paved with concrete. Stormwater shall be directed away from the fuelling area. The site should be sloped to a sump and curbed for spill containment

Washing down general maintenance equipment (not pesticide or fertilizer application equipment) can release large quantities of strong detergent, solvents, oils and greases to the environment. Ideally, solvents and phosphate based detergents should not be used. Wash water should flow to an oil/water separator prior to discharge. This can also be used to collect and treat runoff from the parking lot. At a minimum, equipment washing should be conducted as follows: wash with recycled water only; use a flow control device or anti-backwash valve; wash on graveled areas with effluent flowing to a heavily grassed filter strip.

Spill Contingency

A spill contingency plan is required for all golf courses in New Jersey. To minimize the potential for hazardous substances from the maintenance area to be discharged to the outside environment, the staff must be educated regarding spill contingency measures. Appropriate personal protective equipment, absorbent materials, neutralizng agents, and other containment and remediation measures should be readily available.

Management of Organic Wastes

A golf course will generate a significant amount of biodegradable organic wastes during normal operations and maintenance. Whenever possible, these materials should be composted in a suitable location for use as soil amendments in tree, shrub, and flower beds.

The composting area should be located away from surface waters and downwind from human residential or leisure areas. The bottom should be an impervious material to prevent leaching. If possible, it should be covered to prevent rainfall saturation and runoff. Outside runoff should be directed away from the compost pile.

The pile should have slight positive drainage to a thickly grassed filter strip.

(Much of Chapter 2 adapted from: Greening Your BC Golf Course, Fraser River Action Plan, Environment Canada & Dept. of Fisheries and Oceans. British Columbia, Canada 1997)

Conclusions

The Department believes it is very necessary to integrate pollution prevention and control early in the site planning process. The Best Management Practices generalized in this document are not all-inclusive. Although research is ongoing, much remains to be learned about the impacts of golf courses on the environment. New and innovative techniques are continuously being explored as more information becomes available. Through monitoring effectiveness of BMPs currently recommended and used, a clearer vision can be obtained of the best approach.

However, the central concept remains clear: A properly designed golf course which includes a carefully planned BMP program will minimize the impacts to receiving water bodies and can provide considerable environmental benefits for all.